

# ANNEX N

## Global Warming Potential Values

A Global Warming Potential (GWP) is intended as a quantified measure of the globally averaged relative radiative forcing impacts of a particular greenhouse gas (see Table N-1). It is defined as the cumulative radiative forcing—both direct and indirect effects—over a specified time horizon resulting from the emission of a unit mass of gas relative to some reference gas (IPCC 1996). Direct effects occur when the gas itself is a greenhouse gas. Indirect radiative forcing occurs when chemical transformations involving the original gas produces a gas or gases that are greenhouse gases, or when a gas influences the atmospheric lifetimes of other gases. The reference gas used is CO<sub>2</sub>, and therefore GWP weighted emissions are measured in teragrams of CO<sub>2</sub> equivalents (Tg CO<sub>2</sub> Eq.)<sup>1</sup> The relationship between gigagrams (Gg) of a gas and Tg CO<sub>2</sub> Eq. can be expressed as follows:

$$\text{Tg CO}_2 \text{ Eq} = (\text{Gg of gas}) \times (\text{GWP}) \times \left( \frac{\text{Tg}}{1,000 \text{ Gg}} \right)$$

where,

Tg CO<sub>2</sub> Eq. = Teragrams of Carbon Dioxide Equivalents  
Gg = Gigagrams (equivalent to a thousand metric tons)  
GWP = Global Warming Potential  
Tg = Teragrams (equivalent to a million metric tons)

GWP values allow policy makers to compare the impacts of emissions and reductions of different gases. According to the IPCC, GWPs typically have an uncertainty of ±35 percent (IPCC 1996). The parties to the UNFCCC have also agreed to use GWPs based upon a 100 year time horizon although other time horizon values are available.

*In addition to communicating emissions in units of mass, Parties may choose also to use global warming potentials (GWPs) to reflect their inventories and projections in carbon dioxide-equivalent terms, using information provided by the Intergovernmental Panel on Climate Change (IPCC) in its Second Assessment Report. Any use of GWPs should be based on the effects of the greenhouse gases over a 100-year time horizon. In addition, Parties may also use other time horizons.<sup>2</sup>*

Greenhouse gases with long atmospheric lifetimes (e.g., CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFCs, and SF<sub>6</sub>) tend to be evenly distributed throughout the atmosphere, and consequently global average concentrations can be determined. The short-lived gases such as water vapor, tropospheric ozone, ozone precursors (e.g., NO<sub>x</sub>, CO, and NMVOCs), and tropospheric aerosols (e.g., SO<sub>2</sub> products), however, vary regionally, and consequently it is difficult to quantify their global radiative forcing impacts. No GWP values are attributed to these gases that are short-lived and spatially inhomogeneous in the atmosphere. Other greenhouse gases not yet listed by the IPCC, but are already or soon will be in commercial use include: HFC-245fa, hydrofluoroethers (HFEs), and nitrogen trifluoride (NF<sub>3</sub>).

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<sup>1</sup> Carbon comprises 12/44<sup>ths</sup> of carbon dioxide by weight.

<sup>2</sup> Framework Convention on Climate Change; FCCC/CP/1996/15/Add.1; 29 October 1996; Report of the Conference of the Parties at its second session; held at Geneva from 8 to 19 July 1996; Addendum; Part Two: Action taken by the Conference of the Parties at its second session; Decision 9/CP.2; Communications from Parties included in Annex I to the Convention: guidelines, schedule and process for consideration; Annex: Revised Guidelines for the Preparation of National Communications by Parties Included in Annex I to the Convention; p. 18. FCCC (1996)

Table N-1: Global Warming Potentials (GWP) and Atmospheric Lifetimes (Years)

Gas	Atmospheric Lifetime	100-year GWP <sup>a</sup>	20-year GWP	500-year GWP
Carbon dioxide (CO <sub>2</sub> )	50-200	1	1	1
Methane (CH <sub>4</sub> ) <sup>b</sup>	12±3	21	56	6.5
Nitrous oxide (N <sub>2</sub> O)	120	310	280	170
HFC-23	264	11,700	9,100	9,800
HFC-125	32.6	2,800	4,600	920
HFC-134a	14.6	1,300	3,400	420
HFC-143a	48.3	3,800	5,000	1,400
HFC-152a	1.5	140	460	42
HFC-227ea	36.5	2,900	4,300	950
HFC-236fa	209	6,300	5,100	4,700
HFC-4310mee	17.1	1,300	3,000	400
CF <sub>4</sub>	50,000	6,500	4,400	10,000
C <sub>2</sub> F <sub>6</sub>	10,000	9,200	6,200	14,000
C <sub>4</sub> F <sub>10</sub>	2,600	7,000	4,800	10,100
C <sub>6</sub> F <sub>14</sub>	3,200	7,400	5,000	10,700
SF <sub>6</sub>	3,200	23,900	16,300	34,900

Source: IPCC 1996

<sup>a</sup> GWPs used in this report occur over 100 year time horizon<sup>b</sup> The methane GWP includes the direct effects and those indirect effects due to the production of tropospheric ozone and stratospheric water vapor. The indirect effect due to the production of CO<sub>2</sub> is not included.

Table N-2 presents net GWPs for ozone-depleting substances. These net GWPs incorporate both direct (i.e., “warming,” or positive radiative forcing) and indirect (i.e., “cooling,” or negative radiative forcing, in the case of ODS) effects. Although ozone-depleting substances absorb infrared radiation and contribute to positive radiative forcing, their effect as ozone-depleters also leads to a negative radiative forcing because ozone itself is a potent greenhouse gas. Therefore, the net GWP for ozone-depleting substances takes into account both the direct and indirect effects of the gases (IPCC 1996).

Table N-2: Net Global Warming Potentials for Ozone Depleting Substances\*

Gas	100-year GWP	20-year GWP
CFC-11	3,800	4,900
CFC-12	8,100	7,800
CFC-113	4,800	4,900
HCFC-22	1,500	4,000
HCFC-142b	1,800	4,100
H-1301	5,400	6,100
HCFC-141b	600	1,800
CH <sub>3</sub> Cl <sub>3</sub>	100	300
CCl <sub>4</sub>	1,400	1,900
HCFC-123	90	300
HCFC-124	470	1,500

Source: IPCC 1996

\* Because these compounds have been shown to deplete stratospheric ozone, they are typically referred to as ozone depleting substances (ODSs). However, they are also potent greenhouse gases. Recognizing the harmful effects of these compounds on the ozone layer, in 1987 many governments signed the *Montreal Protocol on Substances that Deplete the Ozone Layer* to limit the production and importation of a number of CFCs and other halogenated compounds. The United States furthered its commitment to phase-out ODSs by signing and ratifying the Copenhagen Amendments to the *Montreal Protocol* in 1992. Under these amendments, the United States committed to ending the production and importation of halons by 1994, and CFCs by 1996. The IPCC Guidelines and the UNFCCC do not include reporting instructions for estimating emissions of ODSs because their use is being phased-out under the *Montreal Protocol*. The effects of these compounds on radiative forcing are not addressed in this report.